International Journal of General Medicine and Pharmacy (IJGMP)
ISSN (P): 2319–3999; ISSN (E): 2319–4006
Vol. 13, Issue 1, Jan–Jun 2024; 97–106

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

EFFECTIVENESS OF PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION STRETCHING ALONG WITH BREATHING EXERCISES ON EXPIRATORY PEAK VOLUME AND CHEST EXPANSION IN SUBJECTS WITH INTRINSIC ASTHMA

Banupriya Pandi[1], Karthika Govindaraj[2], Sivakumar Chinnusamy[3] & Pradeepa Mani[4]

[1]BPT Student, PPG College of Physiotherapy Affiliated to the Tamil Nadu Dr M.G.R Medical University, Chennai

[2]Associate Professor, PPG College of Physiotherapy Affiliated to the Tamil Nadu Dr M.G.R Medical University, Chennai

[3]Principal, PPG College of Physiotherapy Affiliated to the Tamil Nadu Dr M.G.R Medical University, Chennai

[4]Vice Principal, PPG College of Physiotherapy Affiliated to the Tamil Nadu Dr M.G.R Medical University, Chennai

ABSTRACT

Background of the Study: *Intrinsic Asthma is one of the several chronic diseases that are becoming increasingly problematic worldwide. The Global initiative for obstructive lung disease defined as airflow limitation that tends to be not fully reversible and which is usually both progressive and associated with an abnormal inflammatory response of the lungs. In intrinsic Asthma cases the major problem is reduced chest expansion which will leads to breathing difficulty and worsening of the lung volume.*

Objectives: *The objective of the study is find out the combined effectiveness of proprioceptive and diaphragmatic breathing exercises to improve chest expansion and expiratory peak volume in subjects with intrinsic asthma.*

Subjects and Methods: *It is a simple experimental study with convenient sampling technique. The study was conducted at outpatient department of ASHWIN MULTI SPECIALITY HOSPITAL, COIMBATORE. 10 intrinsic asthma subjects with moderate intrinsic were selected based on inclusion criteria with age group 45-55 years The subject were given 8 weeks of PNF Stretching, breathing exercises for about 45 min per session for 5 days. Pre and post-test values of chest expansion and expiratory peak volume was measured by using inch tape and peak flow meter test respectively.*

Result: *The statistical analysis showed that the calculated t value in paired 't' test for improve expiratory peak volume was 17.23 which was greater than the table t value 2.262.The statistical analysis showed that the calculated t value in paired 't' test for chest expansion on inch tape was 11.418 which was greater than the tablet value 2.262. Thus, the resultant of the study shows that there was significant improvement of chest expansion and expiratory peak volume among intrinsic asthma subjects*

Conclusion: *The study concluded that PNF stretch of pectoralis muscle and diaphragmatic breathing exercise on Chest expansion and Peak expiratory flow rate. It is an easy to use, less time consuming, easy to understand and most effective technique.*

Clinical Implications: *PNF Stretching combined with breathing techniques plays a vital role in chest expansion and expiratory peak volume to manage the intrinsic asthma patients.*

KEYWORDS: *Intrinsic asthma , PNF Stretching, Breathing exercises , Inch tape , Expiratory peakflow meter*

Article History

***Received:** 16 Jun 2024 | **Revised:** 16 Jun 2024 | **Accepted:** 25 Jun 2024*

INTRODUCTION

Asthma is a non - communicable, chronic lung disease, characterised by airway obstruction due to muscle spasm by stagnation of the mucus and airway hyper-reactivity to allow biological irritation. Asthma is divided in two types intrinsic asthma and extrinsic asthma[(1)]. Extrinsic (atopic) asthma occurs in the younger age groups and is caused by identifiable trigger factors, such as specific allergens. Patients are usually sensitive to different factors (e.g. pollen, house dust mites, feathers, fur, dust, pollution and, occasionally, food, drugs and exercise) and have a family history of similar sensitivities. Atopic subjects show an immediate skin reaction, elicited by pricking the skin through a drop of antigenic extract. Intrinsic asthma is also known as non-allergic asthma. This means no allergic reaction does not trigger an asthma attack. Intrinsic (non-atopic) asthma tends to occur in the older patient as a chronic condition. It has no apparent allergic cause or family history. This type of asthma is precipitated by, or associated with, chronic bronchitis, strenuous exercise, stress or anxiety[(3)]. The definition of non allergic asthma includes that subset of subjects with asthma and with whom allergic sensitization cannot be demonstrated. These individuals should have negative skin prick test or in vitro specific-IgE test to a panel of seasonal and perineal allergens. Nonallergic asthma appears to be more severe than allergic asthma in many cases and may be less responsive to standard therapy. Although many of the immunopathologic features of nonallergic asthma are similar to those observed with allergic asthma, some differences have been described, including a higher expression of RANTES in mucosa and bronchoalveolar lavage fluid, as well as a higher GM-CSF receptor alpha expression[(6)]. The burden of asthma is immense, with more than 300 million individuals currently suffering from asthma worldwide, about a 10 th of those living in India. The prevalence of asthma has been estimated to range 3- 38% in children and 2- 12% in adults. Being the commonest chronic disorder among children. A recent Indian Study on Epidemiology of Asthma, Respiratory Symptoms and Chronic Bronchitis (INSEARCH) done with 85,105 men and 84,470 women from 12 urban and 11 rural sites in India estimated the prevalence of asthma in India to be 2. 05% among those aged >15 years, with an estimated national burden of 18 million asthmatics.

Non-allergic asthma occurs in 10% to 33% of individuals with asthma and has a later onset than allergic asthma, with a female predominance. About 15 million disability - adjusted life years are lost annually due to asthma, Therefore, represents 1 per cent of the total global disease burden 110. The annual death rate due to asthma is estimated to be 250,000 and the majority of deaths occur in low and middle income countries. Patients from low- and middle - income countries have more severe symptoms than those in high-income countries, possibly due to incorrect diagnoses, poor access to health care, the unaffordability of therapy, exposure to environmental irritants, and genetic susceptibility to more severe disease(3).

Stages of Asthma

Mild persistent, Moderate persistent**,** Severe persistent.

Causes of asthma primarily unknown, Secondarly trigger factors of genetic factors, allergens, irritants, upper respiratory tract infection, occupational asthma, others, conditions associated with asthma[(9)]. Signs and symptoms are breath sound – (vesicular with prolonged expiration), multiple rhonchi both in inspiration and expiration, present and over the lungs and recurrents attacks of dyspnea, cough with mucoid sputum, wheeze, cold weathers, exposure to air – born

allergens, pollens, viral respiratory infection, symptoms may be more in the early morning, symptoms during sleep at night " nocturnal asthma[3]. Asthma is an obstructive lung disease. Narrowing of the airways (bronchospasm) due to constriction of the bronchial muscles in the wall, lead to decreased air flow and difficulty with breathing. Bronchospasm causes decreased peak expiratory flow rate, which in turn leads to decreased PaO2 and increased PaCO2 of the blood. Heart rate increases to compensate for a lack of oxygen being transported in the blood. To increase oxygen during inspiration, hyperventilation will occur in the patient. However work of breathing will be increased due to the narrowed bronchi which make it more difficult to breathe[1]. Investigation of asthma includes x-ray chest (mediastinal air is noted adjacent to the anteroposterior window and airtrapping extends to the neck, especially on the right side), lung function test (spirometry: FEV), complete blood count (may be high eosinophil), sputum culture. Medical management includes Salbutamol, Ipratropium, Nabalised magnesium salphid and Helium mixed with O_2, long acting, **Carticosteriods,** Fluticasone, Momentisone, Ciclesonide, long active Beta adrenoceptor agonist such as Salmeteron, Formoperon. Lukotriene receptor antagonist, Montelukast, Zafirlukast. Mast cell Stabilizer, Cromolyn Sodium,Oral theophylines omalizumab[16]. Physiotherapy managements of non allergic asthma such as **breathing exercises,** diaphragmatic breathing, pursed lip breathing, segmental breathing, active cycle of breathing techniques such as a deep breathing exercises and chest expansion exercise[18].

PNF stretching is stretching technique utilized to increase ROM and flexibility. PNF increases ROM by increasing the length of the muscles and increasing neuromuscular efficiency. Stretching of a muscle with PNF technique improves the length and range of motion via the mechanism of autogenic inhibition. The golgi tendon organs that are present in the muscle will respond to the changes in muscle tension. When the muscle contracts Ib afferent nerve fibers are activated and the impulses will be carried to the spinalcord by those afferent fibers activate inhibitory interneurons. These interneurons will transmit the inhibitory signals to a motor neurons which causes the decrease in the nerve excitability and muscle tension. When the muscle were stretched again there will be decrease in the overlap of actin and myosin filament with increase in the length of muscle fiber, improved muscle viscoelasticity, increased muscle contraction, decrease in the excitability of motor nerve and decreased energy consumption. All these factors contribute to the transformation of information to the central nervous system. So stretching is beneficial to proprioception and for the motor control of nervous system[23].

Diaphragmatic breathing exercise (DB) concentrates on forward movement of the whole abdominal wall. Another technique combines forward movement of the upper abdominal wall with some lateral movement of the lower ribs. DB has been shown strengthening the abdominal muscles, correct abdominal chest wall motion, improve chest expansion, excursion of the diaphragm, airway dilation and expulsion of excess mucus, re-educate the diaphragmatic movements and relax spasmodic muscle contraction. These improvements can then decrease the work of breathing and dyspnea, increase thoracic volume, forced expiratory volume[7]. **Peak expiratory flow rate** is the maximum flow rate generated during a forceful exhalation, starting from full lung inflation. Peak flow testing is a self-assessment lung function test using a peak flow meter to provide an objective measure of airway function based upon peak expiratory flow rate (PEFR). Peak flow is described as the highest airflow velocity that can be achieved, with any drop in the peak flow measurement indicating airway obstruction[6]. An **inch tape** measures or measuring tape is a flexible ruler used to measure size or distance[2].

METHODOLOGY

Study Design

The study design was simple experimental study.

Subjects

The objectives and aim of the study were clearly explained to ethical committee of PPG COLLEGE OF PHYSIOTHERAPY and permission was obtained. After that the study was conduct at ASHWIN MULTI SPECIALITY HOSPITAL, Coimbatore. After getting informed consent and checking the inclusion and exclusion criteria under purposive sampling technique. 10 subjects were selected as an experimental group. The criteria adopted to include the subjects with intrinsic asthma consist of (i) age between 45 to 55 years; (ii)female and male; (iii)moderate intrinsic asthma subjects; (iv)level of chest expansion 2.7cm to 3.6 cm; (v)expiratory peak volume 350l/m to 400l/m.

Methods

Subjects and procedure demonstrated, pre-test measurement of expiratory peak volume were measured with peak flow meter, pre-test measurement of chest expansion were measured with inch tap in all the subjects and recorded as pre-test values. The experimental group was undergone PNF stretching for 15 minutes and breathing exercises for 10 minutes in between 10 minutes rest period. Home exercise programs were 10 minutes. The total treatment duration was 45 minutes. Post-test values were taken using peak flow meter and inch tap for 10 subjects and recorded as post-test values. The data were tabulated and analyzed using test. The 't' test shows that there is significant improvement in intrinsic asthma subjects. Home exercise were explained to the patient.

Description of Experimental Interventions

PNF Stretching

The subjects sitting on a couch with back support to keep spine in a neutral position. both their arms were comfortably extended and hands are placed behind the occipital region. The subject both arms was positioned in glenohumeral horizontal extension, and glenohumeral abduction and external rotation with elbow bent to perform stretch position of pectoral muscle .The therapist hand placed on the subject elbow. The subject was then asked to contract the pectoral muscles to move the limb in the direction of glenohumeral horizontal flexion, in the maintained position of 80° to 90° of glenohumeral abduction and external glenohumeral rotation with elbow bent to meet the 50-60% of resistance applied by the therapist. This isometric contraction was held for 6 seconds. The patient then relaxed and passive stretch in the opposite direction was applied. Repeated 6 times with rest period 30 seconds. The session were given five days per week.

Diaphragmatic Breathing Exercise

The Physiotherapist place hand on the anterior costal margins and upper abdomen to feel the movement occurring. Later , the patient can feel this movement herself. The patient starts by gently breathing out, will relax the shoulder and upper chest, and feeling the lower ribs sink down and in towards the midline. The patient starts by gently breath in at the time abdomen is bulge out but thorax region movement is minimal. 5 days in a week repeated 20 times for 10 mins.

STATISTICAL ANALYSIS

The paired 't' test was used to find out the statistical significance between pre- and post- test values of chest expansion and expiratory peak volume before and after treatment.

Table 1

S. NO	DEMOGRAPHIC DETAILS	MEAN
1	Age 45-50 50-55	49.2
2	Gender ratio (M:F)	2:3
3	No. of patients	10

Expiratory Peak Volume

This table shows the difference between the pre-test and post-test values of experimental group regarding expiratory peak volume by using peak flow meter.

Table 2

TEST INCH TAPE	PRE-TEST	POST TEST	CALCULATED 't' VALUE
MEAN VALUE	376.2	429.5	17. 23
STANDARD DEVIATION	4.137	6.557	

Result

The table shows an analysis of the expiratory peak volume using paired 't test' with 9 degrees of freedom with 5% level of significant. The calculated t value and table value were 17.23and 2.262. The obtained t value is greater than the table t value at the significant level of $p<0.05$ level of significance for 9 degrees of freedom. Hence the statistical report states that there was significant improvement in expiratory peak volume after the application of PNF Stretching and breathing exercises in patients with intrinsic asthma.

Chest Expansion

This table shows the difference between the pre-test and post-test values of experimental group regarding expiratory peak volume by using inch tape.

Table 3

TEST PEAK FLOW MATTER	PRE-TEST	POST-TEST	CALCULATED 't' VALUE
STANDARD DEVIATION	3.14	3.86	11.418
STANDARD DEVIATION	0.12	0.13	

Result

The table shows an analysis of the chest expansion by inch tap using paired 't test' with 9 degrees of freedom with 5% level of significant. The calculated t value and table value were 11.418 and 2.262. The obtained t value is greater than the table t value at the significant level of $p<0.05$ level of significance for 9 degrees of freedom. Hence the statistical report states that

there was significant improvement in chest expansion after the application of PNF Stretching and breathing exercises in patients with intrinsic asthma.

DISCUSSION

Intrinsic asthma is also known as non-allergic asthma. This means no allergic reaction does not trigger an asthma attack. Intrinsic (non-atopic) asthma tends to occur in the older patient as a chronic condition. It has no apparent allergic cause or family history. This type of asthma is precipitated by, or associated with, chronic bronchitis, strenuous exercise, stress or anxiety. **RUTUJA V KAMBLE (2021):** Ethical clearance and participant consent was taken. Study design was Qausi experimental study. The 65 subjects were taken by convenient sampling. Intercostal stretch was applied over 2nd and 3rd rib bilaterally for 10 breaths with 1 minute rest with a 10 repetitions and Outcome measures were assessed before and immediately after giving chest PNF. SPSS 16 software was used to analyses the data. The normality of the data was assessed using parametric paired t test. Significance level was set at 0.05 and 95% Confidence Interval. There is immediate effect of Chest PNF- intercostal stretch on, Respiratory rate, Chest expansion at three level that is axillary, nipple and xiphisternal and Peak expiratory flow rate. It is an easy to use, less time consuming, easy to understand and cost effective technique. **G.SHINE ,ET AL. (2016):** Thirty patients both male and female aged between 20 and 40 years diagnosed with bronchial asthma by the physician were assigned in two groups. Group-1 patients were given diaphragmatic breathing exercises and group-2 patients were given pursed-lip expiration exercises. Both groups received selected intervention for 6 weeks, 5 days in a week, 2 times in a day, and 20 minutes per session. Pre and post-test measures of forced expiratory flow rate were taken by peak expiratory flow meter and chest expansion was measured by inch tape. Data were analysed using Statistical Package for Social Sciences (SPSS) version 17.0 software. The analysis was performed by using students paired t-test. The study shows statistically significant improvement in diaphragmatic breathing exercise group when compared to pursed-lip expiration exercise group. The value of chest expansion has shown 2.04 % improvement in group 1 and 1.01 % in group 2 whereas peak expiratory flow rate (PEFR) showed 16.9 % improvement in group 1 and 2.27 % in group 2. This is a simple experimental study. Total number of 10 intrinsic asthmatic subjects who met the selection criteria were selected and the treatment duration was about 8 weeks. In this study it was discussed that, PNF and diaphragmatic breathing exercises is effective in increase in a chest expansion and expiratory peak volume in intrinsic asthmatic subjects. The statistical analysis also supports the alternate hypothesis.

PNF stretching the respiratory rate decreases after giving chest PNF because respiratory drive is regulated by information from sensory receptors within the airway, lungs and respiratory muscles as well as central and peripheral chemo receptors. The respiratory muscles contraction and relaxation are under control of Golgi Tendon Organ (GTO) which is sensitive to muscle stretch (active or passive). Due to this there is a firing of muscle spindles, which gives this message to Central Nervous System via Alpha and Gamma motor neurons which are directly responsible for initiating muscle contraction. It provides proprioceptive feedback to the respiratory muscles which creates reflex respiratory movement responses and improves rate and depth of respiration. Stretch reflex is used to facilitate the initiation of inhalation and Repeated Contractions are used to facilitate an increase in inspiratory volume. For breathing control, isotonic contractions are also useful. Diaphragmatic breathing exercises play a vital role in rehabilitation of asthmatic patient to gain a functional improvement and independence. Therapeutic interventions are required to improve exercise ability and breathing by augmentation of respiratory muscle function. The aim of breathing exercise interventions is to improve strength, endurance and co-ordination of respiratory muscles.

Deep breathing exercise can reduce the work of breathing by decreasing the respiratory rate and relaxing accessory muscles. Strength and endurance of respiratory muscles can be improved by breathing exercises such as Diaphragmatic breathing(DB).

DB has been shown strengthening the abdominal muscles, correct abdominal chest wall motion, improve chest expansion, excursion of the diaphragm, airway dilation and expulsion of excess mucus, re-educate the diaphragmatic movements and relax spasmodic muscle contractions and reduce thoracic-type breathing. These improvements can then decrease the work of breathing and dyspnea, increase thoracic volume and improve spirometry variables such as vital capacity, forced expiratory volume in one second (FEV1), maximum breathing capacity, tidal volume which results an increased minute ventilation, airway reserve while decreasing breathing frequency and residual volume. Further, DB can increase alveolar gas exchange.Thus, null hypothesis is rejected and alternative hypothesis is accepted. Hence, this Study proved that there were significant improvement in pre and post-test values of inch tape and expiratory peak flow meter in increasing chest expansion and expiratory peak volume by using proprioceptive neuromuscular facilition stretching and diaphragmmatic breathing exercise.

LIMITATIONS

- The study includes a small size only
- The study was only done with intrinsic Asthma.
- The study was done with age group between 45-55.

Further Directions of this Study

- Future studies are recommended with larger samples
- Further studies can be conducted with other treatment techniques.
- This study was done with intrinsic asthma this can be also done with the bronchial Asthma subjects
- This study includes PNF stretching only, other PNF techniques can also be included.
- This study includes only the diaphragmatic exercise, other type of breathing exercises may also be included.

CONCLUSION

The study concludes the PNF stretching and breathing exercise shows significant improvement in the chest expansion and expiratory peak volume in the subjects with intrinsic Asthma.

CONFLICTS OF INTEREST

No potential conflict of interest was reported by the authors.

FUNDING

Nothing to report

ACKNOWLEDGEMENT

First and foremost, my grateful thanks to almighty for his divine blessing and grace in making this project successful and I thank my parents for giving me all this life and opportunity support throughout the course of my study.

I express my sincere gratefulness to Chairman **Dr. L. P. Thangavelu, M.S F.R.C.S** and Correspondent **Mrs. Shanti Thangavelu M.A P.P.G**. Group of Institutions, Coimbatore

For their encouragement and providing the source for the successful of the study. I express my sincere thanks to my **PRINCIPAL Dr. SIVAKUMAR M.P.T (Ortho) MIAP, Ph.D**.; who gave me his precious time and with his vast experience helped me to complete this dissertation successfully.

I express my special thanks and gratitude to my guide **Mrs. G. KARTHIKA MPT** for offering me perceptive inputs and guiding me entirely through the course of my work and without her tired less guidance, support, and constant encouragement this project would not have come through.

My heart full thanks to all the Physiotherapy faculty members for their guidance and Encouragement for my studies I would like to thank my SUBJECT who cooperated to fulfil this project work possible. I privileged to express my thanks to my dearest friend especially **CONQUERORS** for their marvelous support, help and motivation and encouragement throughout the study.

AUTHORS' CONTRIBUTIONS

I was understand my agreement to participation in this study and i am not waiving any of my legal rights. I confirm that **MS.BANUPRIYA P/ MRS. G. KARTHIKA, MPT., ASSOCIATE PROFESSOR** have explained me that purpose of the study, the study procedure and possible risk that i may experience i have read and i have understood this concern to participate as in subject in this study.

REFERENCES

1. *Ramadas Nayak Rakshatha Nayak. EXAM PREPARATORY MANUAL FOR UNDERGRADUATES: pathology. 2018.*
2. *Bockenhauer SE, Chen H, Julliard KN, Weedon J. Measuring thoracic excursion: reliability of the cloth tape measure technique. The Journal of the American Osteopathic Association [Internet]. 2007 May 1;107(5):191–6. Available from:*
3. *Lai CKW, Beasley R, Crane J, Foliaki S, Shah J, Weiland S. Global variation in the prevalence and severity of asthma symptoms: Phase Three of the International Study of Asthma and Allergies in Childhood (ISAAC). Thorax. 2009 Feb 22;64(6):476–83.*
4. *Pollock ML, Gaesser GA, Butcher JD, Despr??s JP, Dishman RK, Franklin BA, et al. ACSM Position Stand: The Recommended Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory and Muscular Fitness, and Flexibility in Healthy Adults. Medicine & Science in Sports & Exercise. 1998 Jun;30(6):975–91.*

5. *Debouche S, Pitance L, Robert A, Liistro G, Reychler G. Reliability and Reproducibility of Chest Wall Expansion Measurement in Young Healthy Adults. Journal of Manipulative and Physiological Therapeutics [Internet]. 2016 Jul [cited 2020 Jan 15];39(6):443–9.*
6. *Mistry HM, Kamble RV. Immediate effect of Chest Proprioceptive Neuromuscular Facilitation on Respiratory Rate, Chest Expansion and Peak Expiratory Flow Rate in patients with Chronic Obstructive Pulmonary Disease. International Journal of Physiotherapy and Research. 2021 Jan 11;9(1):3724–9.*
7. *Shine G. "Comparison of Effectiveness of Diaphragmatic Breathing and Pursed-Lip Expiration Exercises in Improving the Forced Expiratory Flow Rate and Chest Expansion in Patients with Bronchial Asthma." International Journal of Physiotherapy. 2016 Apr 1;3(2).*
8. *Chaurasia BD. Human anatomy, New Delhi, India: CBS Publisher, 2004.*
9. *Asthma and Allergy Foundation of America | AAFA | Home [Internet]. Asthma & Allergy Foundation of America.*
10. *Janssens JP, Krause KH. Pneumonia in the very old. The Lancet Infectious diseases [Internet]. 2004 [cited 2019 Sep 15];4(2):112–24.*
11. *King D. Physiotherapy and the Ventricular Assist Device. Physiotherapy. 1991 Apr;77(4):255–8.*
12. *Morrow DA, Braunwald E. Future of Biomarkers in Acute Coronary Syndromes. Circulation. 2003 Jul 22;108(3):250–2.*
13. *Gaude G, Savadatti R, Hattiholi J. Postural correction for kyphosis improves the dyspnea index and pulmonary functions in patients with chronic obstructive pulmonary disease: A randomized trial over 12 weeks. International Journal of Health & Allied Sciences. 2014;3(1):44.*
14. *14. Abstracts 801 to 1071. Hepatology. 2006 Jan 1;44(S1):487A587A.*
15. *Siva Jyothi N, Senthil Selvam P, Ahmedullah Md, Yatheendra KG, Subramanian SS, Paul*
16. *J. Effectiveness of PNF stretch of pectoralis major muscle on pulmonary function in COPD patients. International journal of health sciences. 2022 May 31;13332–41.*
17. *Huang H, Chen J, Yi C, Qian P, Weng H. Novel insights in RNA modifications: From basic to translational research. Frontiers Media SA; 2023.*
18. *Han MK, Dransfield MT, Martinez FJ. Chronic obstructive pulmonary disease: Definition, clinical manifestations, diagnosis, and staging. Uptodate. May. 2018;14.*
19. *de Sá RB, Pessoa MF, Cavalcanti AG, Campos SL, Amorim C, de Andrade AD. Immediate effects of respiratory muscle stretching on chest wall kinematics and electromyography in COPD patients. Respiratory physiology & neurobiology. 2017 Aug 1;242:1-7.*
20. *Rehman A, Ganai J, Aggarwal R, Alghadir AH, Iqbal ZA. Effect of Passive Stretching of Respiratory Muscles on Chest Expansion and 6-Minute Walk Distance in COPD Patients. International Journal of Environmental Research and Public Health. 2020 Jan;17(18):6480.*

21. *Cabral LF, D'Elia TC, Marins DS, Zin WA, Guimarães FS. Pursed lip breathing improves exercise tolerance in COPD: a randomized crossover study. Eur J Phys Rehabil Med. 2015 Feb;51(1):79-88.*

22. *Slupska L, Halski T, Żytkiewicz M, Ptaszkowski K, Dymarek R, Taradaj J, Paprocka- Borowicz M. Proprioceptive neuromuscular facilitation for accessory respiratory muscles training in patients after ischemic stroke. InAdvances in Pulmonary Medicine: Research and Innovations 2019 (pp. 81-91). Springer, Cham.*

23. *. Wanderley D, Lemos A, Moretti E, Barros MM, Valença MM, de Oliveira DA. Efficacy of proprioceptive neuromuscular facilitation compared to other stretching modalities in range of motion gain in young healthy adults: a systematic review. Physiotherapy theory and practice. 2019 Feb 1;35(2):109- 29.*

24. *Siva Jyothi, N., Senthil Selvam, P., Ahmedullah, M., Yatheendra, K. G., Subramanian, S. S., & Paul, J. (2022). Effectiveness of PNF stretch of pectoralis major muscle on pulmonary function in COPD patients. International Journal of Health Sciences, 6(S1), 13332–13341.*

25. *Mahin Hamechi, fahm Roudia, Javad Malekadehb, Mohse Ebrahimic, Amir Mirhaghib, Mohammad TaghiShakerid Comparison between Emergency Severity In dexpluspeak flowmeter and Emergency Severity Indexin the dyspneicpatients with chronic obstructive pulmonary disease: A randomized clinical trial : Turkish Journal of Emergency Medicin (2019).*

26. *Mohan V, Dzulkifli NH, Justine M, Haron R, H LJ, Rathinam C, Intrarater Reliability of Chest Expansion using Cloth Tape Measure Technique Bangladesh Journal of Medical Science Vol. 11 No. 04 Oct'12.*